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Two-dimensional mapping of electron temperature in the PM-cusped helicon plasma thruster

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A helicon plasma thruster (HPT) has actively investigated over the last decades [1,2]. The HPT is electrodeless and does not require a neutralizer, that is expected to be a new space transportation technology with long lifetime and high-power operation. However, the HPT performance has been lower than that of mature electric propulsion devices and needs to be improved.

The HPT has the simple configuration consisting of a glass tube, an rf antenna, and a magnetic nozzle (MN). In the HPT, the plasma generated by the rf plasma source is transported downstream along the magnetic field lines, and spontaneously accelerated via several phenomena in the MN when the plasma expands along the magnetic field. This process is responsible for the thrust generation, since the reaction force of the plasma acceleration is exerted somewhere and somehow [2]. In one of the HPT laboratory experiments, energy and momentum losses to the wall have been measured in the plasma source [3]. It is expected that the high temperature electrons existing near the inner wall would enhance the sheath voltage, the resultant ion acceleration energy to the wall, and the energy loss to the wall. Previous experiment has used a cusp magnetic field inside the source to geometrically isolated the plasma from the source wall, resulting in the reduction of the loss area. The experiment has shown the 30 % thrust efficiency, while an additional upstream solenoid is installed to create the cusp field [4].

For the practical application of the HPT, replacing the solenoid with permanent magnets (PMs) would be effective because of the reduction of the consumed electric power. A recent experiment replacing the upstream solenoid by the PMs has shown a similar momentum flux to that using two solenoids [5]. However, detailed changes in the plasma parameters have not been identified owing to the lack of data of the plasma parameters. In the present study, the spatial distribution of the plasma parameter in the PM-cusped HPT is measured and compared between "no cusp field" and "cusp field by the two solenoids" cases.

Figures 1 shows the schematic diagrams of the experimental setups tested here. The rf plasma source is continuously attached to a cylindrical stainless steel diffusion chamber. The plasma source configuration with no cusp field and with cusp field by two solenoids, with cusp field by the PM array are drawn in Fig.1(a), (b), respectively. The rf compensated Langmuir probe (CLP) is used to measure the *I-V* characteristic curve, from which the electron temperature is determined with assuming a Maxwellian distribution. The plasma density is estimated from an ion saturation current of another planar LP (PLP).

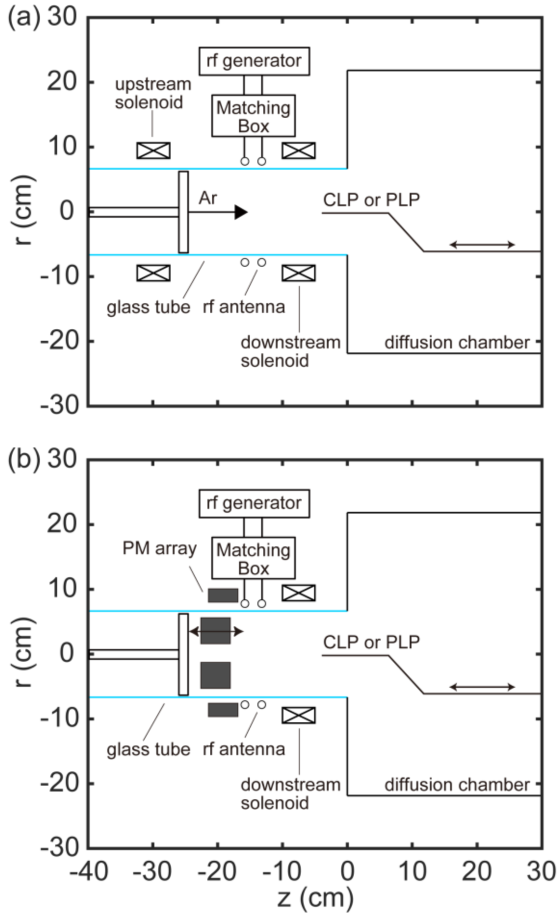

Figure 1. The schematic diagrams of the experimental set up. The plasma source configuration with (a) "no cusp field" and "with cusp field by two solenoids", (b) "with cusp field by the PM array", respectively.

The results show that the high temperature electrons created near the rf antenna is transported toward the source center along the convergent magnetic fields, by which the low electron temperature region is formed near the radial wall. Detailed results will be described in the presentation.

References

[1]C. Charles, *J. Phys. D:Appl. Phys*. **42**, 163001 (2009).
[2]K. Takahashi, *Rev. Mod. Plasma Phys*. **3**, 3 (2019).
[3]K. Takahashi *et al*., *Sci. Rep*. **10**, 1061 (2020).
[4]K. Takahashi, *Sci. Rep*. **12**, 18618 (2022).
[5]Y. Nakahama and K. Takahashi, *AIP adv*. **14**, 015059 (2024).